BRUHAT BENGALURU MAHANAGARA PALIKE

NAME OF WORK:- Improvements to roads, drains and construction of culverts at Central Excise layout, hegdenagara and Surrounding areas in Ward No.06

ESTIMATE COST:- 200.00 Lakhs

CLIENT:

EXECUTIVE ENGINEER
PROJECT YELAHANKA ZONE
BBMP, BENGALURU

DPR CONSULTANTS:

VSR CIVIL INFRA PVT. LTD.
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APPENDIX

BIS = Bureau of Indian Standards

BC = Bituminous Concrete

BBD = Benkelman Beam Deflection

BBMP = Bruhat Bengaluru Mahanagara Palike

BWSSB = Bengaluru Water & Sewerage Supply Board

BOQ = Bill of Quantities

CBR = California Bearing Ratio

CH = Chainage

DBM = Dense Bituminous Macadam

DTM = Digital Terrain Model

GSB = Granular Sub Base

HIP = Horizontal Intersection Points

IRC = Indian Road Congress

KM = Kilometer

MSA = Multi Scale Axle

MORT & H = Ministry Of Road Transport & Highway

O/H = Over Head

OFC = Optical Fibre Cables

PCU = Passenger Car Unit

PWD = Public Work Department

PI = Plasticity Index

PMC = Project Management Consultant

RCC = Reinforced Cement Concrete

ROW = Right of Way

TBM = Temporary Bench Marks

WMM = Wet Mix Macadam

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CHAPTER 1

PROJECT BACKGROUND

1.1. INTRODUCTION

Bangalore is the capital of Karnataka. It is located on the Deccan Plateau in the south-eastern part of Karnataka. Bangalore is India's third most populous city and fifth-most populous urban agglomeration. Bangalore is well known as a hub for India's Information Technology sector. It is among the top 10 preferred entrepreneurial locations in the world.

Bangalore is a large city and growing metropolis and it is home to many well recognized colleges and research institutions. The various public sector heavy industries, software companies, aerospace, telecommunications, and defense organizations are located in this city. Bangalore is also known as the Silicon city of India because of its position as the nation's leading IT exporter. A demographically diverse city, Bangalore is a major economic and cultural hub and the second fastest growing major metropolis in India.

The Government of Karnataka in its Budget 2015-16, has proposed to improve and develop roads in Core-Bangalore as well as newly added zones, as it is most essential to facilitate the smooth traffic movement and also improve the existing road condition.

This will add up to the beautification of roads in Bangalore as well as smoothen the pedestrian movement on the existing footpaths. As part of this, Bruhat Bengaluru Mahanagara Palike (BBMP) is desirous of obtaining consultancy services for the preparation of Design Report for roads under South Division. BBMP has taken up substantial projects covering the limits specified involving roads, footpaths, drainage works etc.

VSR CIVIL INFRA PVT LTD has been appointed as a consultant to perform the services. This Report deals with the approach, methodology, investigation details of project roads and the role of Consultants.

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1.2. OBJECTIVES

Objectives of the project are as listed below:

- To conduct necessary survey studies, investigations and designs required to prepare Design Report for the selected roads in Bangalore city.
- To prepare BOQ, estimates and specifications based on the detailed designs.
- To prepare tender documents.

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CHAPTER 2

FIELD INVESTIGATION

The objectives of services as detailed in the scope of work for the Project are achieved by ensuring the consultant's presence at site and active involvement in all the activities, it is ensured that the universally accepted engineering practices are followed.

The basic aim of field investigation and analysis is to identify technically and economically feasible solution to improvements / widening of the existing road, if any. These improvements include the formulation of suitable cross section through widening / improvements to the existing pavement drain system, footpath and facilities to the road users.

2.1 RECONNAISSANCE SURVEY

The reconnaissance survey is carried out along the road to and collected the information related to various features, intersections and any other important details before carrying out the detailed topographical survey. The data derived from the reconnaissance surveys are utilized to plan the detailed survey and investigations.

2.2 DETAILED TOPOGRAPHICAL SURVEY

The topographical survey is a back bone for the planning and design of improvements to the roads. The detailed field survey is carried out using high precision instruments, Total stations. The topographical survey was carried out by setting up a Temporary Bench Mark (TBM) and control stations. The data from the topographic surveys is available in (x, y, z) format for use in a sophisticated digital terrain model (DTM).

TBM is established at site on permanent structure and marked with yellow paint indicating the TBM number. Topographic survey is carried out along the existing center line within the Right of Way (ROW) or building line. All the cardinal points such as horizontal intersection points (HIP`s), centre points and transit points etc. are fixed. The pair of reference pillars is fixed on either side of the centre-line at safe places within the ROW.

The details such as structures (bridges, culverts etc.) utilities, existing roads, electric and telephone installations (both O/H as well as underground), buildings, fencing and trees (with

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girth greater than 0.3 meter) oil and gas lines etc. falling within the ROW or building to building are captured.

The system of check was implemented to ensure the accuracy of all survey information. A precision of 1:10000 was adopted in DTM collection. DTM survey was repeated wherever the requisite precision was not met.

Following land features shall be captured and presented in drawings. All the notations/symbols (Legends) shall be agreed with the Client in advance of the execution.

- Existing road pavement surface, earthen shoulder and width of pavement along with all other pertinent road details-centerline of carriageway, pavement edge, shoulder edge, embankment/cutting edges top and bottom, side drains, signs, kilometer posts etc.
- All religious places-temples, mosques, churches, graveyards etc. including location, building lines and clear dimensions of compound walls and extensions.
- Location of roadside drains, clearly identifying the type (open/close), width of drain, including the beginning and end of drains. All water features within ROW i.e. ponds, lakes, streams, canals should be recorded.
- Identification of bridge, culverts and other structures along the alignment with the flow direction, invert level.
- Trees (position, species and girth measured 1.2m from ground level).
- Building fronts or outlines where they encroach within the corridor.
- Railway level crossings.
- Any over crossing or under crossing of the road by road or rail.
- Electric transformers, mast, towers, etc.
- All telephonic lines, OFC lines, Private OFC lines, water Pipes above and below the ground, Electricity lines.

The width of the survey corridor will be increased to collect data such as existing road junctions, where the adjoining road will be surveyed for a distance of 100m to a width of 5m from the edge of road formation / stream on either side. Building outlines will be surveyed where they encroach into the corridor as defined in the data sheet.

The cross section survey should include but not limited to the following :

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For Existing Road:

- At center line of existing carriageway.
- At carriageway edges.
- At the points between center line and edge of carriageway.
- At paved shoulder / earthen shoulder / footpath edges.
- Ata intersection of embankment / cut with natural ground.

Further, points at 10m intervals of at location of change in ground.

For Culverts:

- At center line of existing carriageway.
- At carriageway edges.
- At paved shoulder / earthen shoulder / footpath edges.
- At top of head wall.
- At culvert invert level.
- At points up stream & downstream along the channel.

Longitudinal and Cross-Section:

The longitudinal levels along the road are taken at every 25 m interval & it is reduced to 10 m.at curves and the features like buildings, structures, drain line, utilities etc are covered. Longitudinal section of cross roads (about 5m) for design and quantity estimate purposes is carried out.

Base map showing the alignment of existing road, ROW, buildings, drains, trees, electrical lines, poles, OFC, etc. is prepared. The raw data is processed using software to get the co-ordinate files. Base map is updated with the walk over survey along with concerned authority engineer to update any missing information.

2.3 ROAD INVENTORY AND PAVEMENT CONDITION SURVEY

The roads sections & various intersections are studied from the available maps & other data before starting up the Road Inventory. The typical features along the existing alignment with the ROW & land use pattern on both sides of road are studied. Conditions & widths of Pavement, Drain & footpath are noted. The drainage condition along the road is studied from the soil type & the local enquiry. During inventory all the details like type of pavement, shoulder, drain and any other relevant features are recorded and presented in accordance with IRC 82, 37 & relevant codes.

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Pavement Condition by visual inspection:

The visual survey is conducted and various details of the existing pavement are recorded.

1. Pavement condition (extent of potholes, cracks, rutting, evenness, etc.)
2. Shoulder condition (surface, potholes, height above or below carriageway, evenness)
3. Side drain (type, condition)

The Road Inventory data sheet is enclosed in the Annexure 7.1 the details of Road Inventory of the project road are described below.

HORIZANTAL AND VERTICAL ALIGNMENT

The horizontal alignment on the project road is rough. The project roads are having relatively good geometrics. The vertical alignment of the project road is flat except for some locations and also at cross roads where the project roads runs at a higher, lower and same levels.

EXISTING FOOTHPATHS

Footpaths exists on both sides, top slab of drains are majorly BS slabs on both left hand side and right hand side. The slabs are in good condition, can be retained and resetting of the footpath slabs has been proposed, also damaged slabs will be replaced. Encroachments of footpaths were observed at few locations near the junctions.

EXISTING ROAD SIDE DRAINAGE SYSTEM

Longitudinal drains were found on the project road. Where ever the drains were observed it was placed on the outer edge of the footpath towards the property line. For most of the stretch the drains have been provided with cover slabs and rarely open type. Removing and resetting of drain slabs and repair of the damaged drain has been proposed along with de-silting of drain for the project road.

INTERSECTION JUNCTIONS & PEDESTRIAN CROSSING

Seven intersections has been observed all long the project road with two major intersections namely Road intersection. It was observed road markings are faded off or erase and pedestrian crossings were missing at the junctions. Project road runs through urban area and has a mix of fast and slow moving

TRAFFIC

Based on the site visit it was observed that the major part of the traffic on the project road comprises of two-wheelers followed by cars, auto rickshaws and public transport services.

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CHAPTER 3

SOCIO - ECONOMIC ZONE

3.1 GENERAL

Bangalore also rendered Bengaluru is the capital of the Indian state of Karnataka. Located on the Deccan Plateau in the south-eastern part of Karnataka, Bangalore is India's third most populous city and fifth-most populous urban agglomeration. Bangalore is well known as a hub for India's information technology sector. It is among the top 10 preferred entrepreneurial locations in the world.

A succession of South Indian dynasties ruled the region of Bangalore until in 1537 AD, Kempe Gowda—a feudatory ruler under the Vijayanagara Empire—established a mud fort considered to be the foundation of modern Bangalore. Following transitory occupation by the Marāthās and Mughals, the city remained under the Mysore kingdom, which is now a part of the Indian state of Karnataka. Bangalore continued to be a cantonment of the British and a major city of the Princely State of Mysore which existed as a nominally sovereign entity of the British Raj. Following the independence of India in 1947, Bangalore became the capital of Mysore state, and remained capital when the new Indian state of Karnataka was formed in 1956.

As a large and growing metropolis, Bangalore is home to many well-recognized colleges and research institutions in India. Numerous public sector heavy industries, software companies, aerospace, telecommunications, and defense organizations are located in the city. Bangalore is known as the Silicon Valley of India because of its position as the nation's leading IT exporter. A demographically diverse city, Bangalore is a major economic and cultural hub and the second fastest growing major metropolis in India.

3.2 Geography

Bangalore lies in the southeast of the South Indian state of Karnataka. It is in the heart of the Mysore Plateau (a region of the larger Precambrian Deccan Plateau) at an average elevation of 900 m (2,953 ft).It is located at WikiMiniAtlas 12°58′N 77°34′E / 12.97°N 77.56°E / 12.97; 77.56 and covers an area of 741 km² (286 mi²). The majority of the city of Bangalore lies in the Bangalore Urban district of Karnataka and the surrounding rural areas are a part of the Bangalore Rural district. The Government of Karnataka has carved out the new district of Ramanagara from the old Bangalore Rural district.

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The topology of Bangalore is flat except for a central ridge running NNE-SSW. The highest point is Vidyaranyapura Doddabettahalli, which is 962 m (3,156 ft) and lies on this ridge. No major rivers run through the city, though the Arkavathi and South Pennar cross paths at the Nandi Hills, 60 km (37 mi.) to the north. River Vrishabhavathi, a minor tributary of the Arkavathi, arises within the city at Basavanagudi and flows through the city. The rivers Arkavathi and Vrishabhavathi together carry much of Bangalore's sewage. A sewerage system, constructed in 1922, covers 215 km² (133 mi²) of the city and connects with five sewage treatment centers located in the periphery of Bangalore.

3.3 Climate

Bangalore experiences a tropical savanna climate with distinct wet and dry seasons. Due to its high elevation, Bangalore usually enjoys a more moderate climate throughout the year, although occasional heat waves can make things very uncomfortable in the summer. The coolest month is December with an average low temperature of 15.4 °C and the hottest month is April with an average high temperature of 32.8 °C. The highest temperature ever recorded in Bangalore is 38.9 °C(recorded in March 1931) and the lowest ever is 7.8 °C (recorded in January 1884). Winter temperatures rarely drop below 12 °C (54 °F), and summer temperatures seldom exceed 34–35 °C (<100 °F). Bangalore receives rainfall from both the northeast and the southwest monsoons and the wettest months are September, October and August, in that order. The summer heat is moderated by fairly frequent thunderstorms, which occasionally cause power outages and local flooding. The heaviest rainfall recorded in a 24-hour period is 179 millimeters (7.0 in) recorded on 1 October 1997.

Climate data for Bangalore

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °C (°F)	26.7 (80.1)	29.3 (84.7)	32.4 (90.3)	32.8 (91.0)	31.3 (88.3)	28.7 (83.7)	26.9 (80.4)	27.1 (80.8)	28.0 (82.4)	27.5 (81.5)	26.4 (79.5)	25.6 (78.1)	28.56 (83.41)
Average low °C (°F)	15.8 (60.4)	16.3 (61.3)	18.9 (66.0)	21.0 (69.8)	20.7 (69.3)	19.5 (67.1)	19.0 (66.2)	18.8 (65.8)	18.5 (65.3)	18.2 (64.8)	17.5 (63.5)	15.4 (59.7)	18.30 (64.94)
Rainfall mm (inches)	2.7 (0.106)	7.2 (0.283)	4.4 (0.173)	46.3 (1.823)	119.6 (4.709)	80.6 (3.173)	110.2 (4.339)	137.0 (5.394)	194.8 (7.669)	180.4 (7.102)	64.5 (2.539)	22.1 (0.87)	969.8 (38.181)
Avg. rainy days	0.2	0.5	0.4	3.0	7.0	6.4	8.3	10.0	9.3	9.0	4.0	1.7	59.8
Mean monthly sunshine hours	263.5	248.6	272.8	258.0	241.8	138.0	111.6	114.7	144.0	173.6	189.0	211.8	2,367.4

Source #1: WMO[38]

Source #2: HKO (sun only, 1971–1990)[39]

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3.4 Transport

3.4.1 Air

Bengaluru is served by the Bengaluru International Airport which started operations from 24 May 2008. The new Bengaluru International Airport is located in Devanahalli.

The city was earlier served by the HAL Airport which was India's fourth busiest airport. It is now the fourth busiest airport in India in terms of passenger traffic and the number of air traffic movements (ATMs) with about 280 per day. The airport is around 40 km from the city centre. The most hassle-free way to commute is by taxi. Meru cabs and Easy cabs have taxis present in the rank at the airport. There are also certain private cab companies.

3.4.2 Rail

A rapid transit system called the Namma Metro is being built. A 7 km stretch from Bayappanahalli to MG Road was opened to public on 20 October 2011. Once completed, this will encompass a 42.3 km (26.3 mi) elevated and underground rail network comprising 41 stations. It is expected to connect central locations in Bangalore to Devanahalli and the Chikballapur regions. This much-delayed project is the city's primary response to the worsening intra-city transport infrastructure which has become a major deterrent to continued business growth. Bengaluru comes under the South Western Railway zone of the Indian Railways. Bangalore City Railway station and Yesvantpur Junction connect it to the rest of the country through the Indian Railways. The Bangalore Rajdhani Express connects the city to New Delhi, the capital of India. Bangalore is also connected by rail to most cities in Karnataka, as well as Mumbai, Chennai, Kolkata, Hyderabad, Indore, Mysore, Bhagalpur, Tatanagar, Trivandrum, Bhopal, and other major cities in India. The sprawling Rail Wheel Factory is Asia's second largest manufacturer of Wheel & Axle for Railways and headquartered in Yelahanka, Bangalore.

3.4.3 Road

Three-wheeled, green and black auto-rickshaws, referred to As autos, are a popular form of transport. They are metered and can accommodate up to three passengers. Taxis, commonly called City Taxis, are usually available only on call. Taxis are metered and are generally more expensive than auto-rickshaws. Buses operated by Bangalore Metropolitan Transport Corporation (BMTC) are an important means of public transport available in the city, and are highly reliable. While commuters can buy tickets on boarding these buses, BMTC also provides an option of a bus pass to frequent users. BMTC runs air-conditioned luxury buses on

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major routes, and also operates shuttle services from various parts of the city to the Bengaluru International Airport. The Karnataka State Road Transport Corporation operates 6,918 buses on 6,352 schedules, connecting Bangalore with other parts of Karnataka as well as other states. The main bus depots that BMTC maintains are the Kempegowda Bus Station, locally known as "Majestic bus stand", Shantinagar Bus Depot, and Shivajinagar Bus Depot.

3.5 Economy

Bengaluru's ₹52,346 crores (US$9.47 billion) economy (2006–07 Net District Income) makes it one of the major economic centers in India, with the value of city's exports totaling ₹43,221 crores (US$7.82 billion) in 2004–05. With an economic growth of 10.3%, Bengaluru is the second fastest growing major metropolis in India, and is also the country's fourth largest fast moving consumer goods (FMCG) market. The Forbes magazine considers the city as one of "The Next Decade's Fastest-Growing Cities". With a per capita income of ₹74,709 (US$1,352.23) in 2006–07, the city is the third largest hub for high net worth individuals and is home to over 10,000 dollar millionaires and about 60,000 super-rich people who have an investable surplus of ₹4.5 crores (US$1 million) and Rs. 50 Lakhs (US$ 90,500) respectively.

The headquarters of Infosys, India's third largest IT company, is located in Bengaluru.

The headquarters of several public sector undertakings such as Bharat Electronics Limited (BEL), Hindustan Aeronautics Limited (HAL), National Aerospace Laboratories (NAL), Bharat Heavy Electricals Limited (BHEL), Bharat Earth Movers Limited (BEML) and HMT (formerly Hindustan Machine Tools) are located in Bangalore. In June 1972 the Indian Space Research Organization (ISRO) was established under the Department of Space and headquartered in the city.

Bengaluru is called the Silicon Valley of India because of the large number of information technology companies located in the city which contributed 33% of India's Rs. 144,214 crores (US$ 26 billion) IT exports in 2006–07. Bangalore's IT industry is divided into three main clusters — Software Technology Parks of India (STPI); International Tech Park, Bangalore (ITPB); and Electronics City. UB City, the headquarters of the United Breweries Group, is a high-end commercial zone.[61] Infosys and Wipro, India's second and fourth largest software companies are headquartered in Bangalore, as are many of the global SEI-CMM Level 5 Companies.

The growth of IT has presented the city with unique challenges. Ideological clashes sometimes occur between the city's IT moguls, who demand an improvement in the city's

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infrastructure, and the state government, whose electoral base is primarily the people in rural Karnataka. The encouragement of high-tech industry in Bangalore, for example, has not favored local employment development, but has, instead, increased land values and forced out small enterprise. The state has also resisted the massive investments required to reverse the rapid decline in intra-city transport which has already begun to drive new and expanding businesses to other centers across India. Bengaluru is a hub for biotechnology related industry in India and in the year 2005, around 47% of the 265 biotechnology companies in India were located here; including Biocon, India's largest biotechnology company.

3.6 Karnataka State Economy

Karnataka is one of the high economic growth states in India with the GSDP (Gross State Domestic Product) at constant prices growth of 8.9% in the fiscal year 2010-2011. Karnataka is the seventh largest GDP producing states in India. The State GSDP is expected to grow at 6.4% in 2011-12 which is slightly less than India's GDP estimate of 6.9% for the period. Per capita GSDP during 2010–2011 was Rs 47310 at constant prices. Karnataka is best known for its software industry and now biotechnology and the state has recorded the highest growth rates in terms of GDP and per capita GDP in the last decade compared to other states. In the last decade, Karnataka surpassed all other states in India, pushing Karnataka's per capita income in Indian Rupee terms to sixth place.

The contribution of primary, secondary and tertiary sectors to Karnataka's GSDP (at 2004-05 constant prices) in 2010-11 has been 16.06%, 28.48% and 55.35% respectively. The sectoral composition of Karnataka GSDP is comparable with sectoral composition of India's GDP of 14.4 % (Primary), 27.9% (Secondary) and 57.7 % (Tertiary sector). Between 2005-06 and 2010-11, average growth rate of Karnataka GSDP is 8.6 % which is same as India's GDP growth during the period. However, in the first three years that is from 2005-06 to 2007-08 the state GSDP has averaged 11.5 % with highest growth rate of 12.9% in 2007—08. But in the last three years from 2008-09 to 2010-11 the growth in GSDP has averaged only 5.7 %.

Karnataka is the manufacturing hub for some of the largest public sector industries in India, including Hindustan Aeronautics Limited, National Aerospace Laboratories, Bharat Heavy Electricals Limited, Indian Telephone Industries, Bharat Earth Movers Limited and Hindustan Machine Tools, which are based in Bangalore. Many of India's premier science and technology research centers, such as Indian Space Research Organization, Central Power Research Institute, Bharat Electronics Limited and the Central Food Technological Research

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Institute, are also headquartered in Karnataka. Mangalore Refinery and Petrochemicals Limited is an oil refinery located in Mangalore.

3.7 Contribution to economy by sector

Karnataka has natural advantages that serve it well for diversified agricultural production. Agriculture and allied sectors in Karnataka grew in 2009-10 by 3.4 % and 12.9% in 2010-11. In the year 2011-12, the sector is expected to grow at a rate of -3.9% having affected by a severe drought. Karnataka has been credited by the Planning Commission for presenting separate agriculture budget.

Karnataka is the largest producer of coarse cereals, coffee and raw silk among the states in India. The income generated from horticulture constitutes over 40% of income generated from agriculture and its is about 17% of the state's GDP. In floriculture, Karnataka occupies the second position in India in terms of production. Silk industry is concentrated mainly in the North Bangalore regions of Muddenahalli, Kanivenarayanapura and Doddaballapura.

Gold, iron ore, quartz, limestone, manganese, kyanite and bauxite are some of the minerals that are found in Karnataka. Major mines of manganese and iron ore are located at SandurinBellarydistrict.

Karnataka leads the nation in information technology and biotechnology. Bangalore is the home of the largest bio cluster in India with total revenues of over Rs. 14 billion and having 158 of the 320 companies working on biotechnology in India.

Karnataka has a headcount of over 6800 scientists involved in biotech research.

Capital Bangalore is well known as a hub for India's information technology sector. Large number of information technology companies located in the city which contributed 33% of India's Rs. 144,214 crores (US$ 32 billion) IT exports in 2006–07. Infosys and Wipro, India's second and third largest software companies are headquartered in Bangalore.

The state is home to some of the premier educational and research institutions of India such as the Indian Institute of Science, the Indian Institute of Management, the National Institute of Technology Karnataka and the National Law School of India University. The State boasts of the largest concentration of higher educational institutions like Medical and Engineering colleges.

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Karnataka, with a geographical area of 1,91,791 sq.kms, is the eighth largest state of India, accounting for 5.83 % of the total area of the country. It is situated in the southern part of the country and is surrounded by the states of Maharashtra and Goa in the north and the northwest, Arabian Sea in the west, Tamil Nadu and Kerala in the south and Andhra Pradesh in the east. Administratively, the state has been divided into 27 districts, which are further sub-divided into taluks and development blocks. Karnataka is endowed with a variety of physiographic features ranging from cool blue seas, verdant forests, breathtaking waterfalls and an endless stretch of plains and rolling hills that are about to touch the sky.

3.8 Economic Situation

The broad social and economic profile of the state during the past decade has undergone tremendous change. State Domestic Product (SDP), popularly known as 'State Income', is an important and reliable indicator to measure the growth of the economy as well as level of development in various socio-economic sectors of a state. The per capita Net State Domestic Product is used to determine the absolute as well as the relative performance of the State Economy. In other words State Domestic product (SDP) and Per Capita Income (PCI) reflect overall performance of economy of the State and also the well being of the people during a given period of time.

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CHAPTER 4

DESIGN BRIEF

4.1 GENERAL

The road development project involves huge investments and hence requires good investigation, analysis and design before the implementation decision. The objective of setting design standards is to confirm the proposed road with the applicable code of practice.

For the present road it is proposed to follow design standards as per Indian Road Congress (IRC) codes of practice, guidelines and special publications and applicable MoRT&H circulars and reports.

The design is carried out by considering & understanding the existing conditions of the road / structures. Based on the data collected during investigation, the applicable improvements to the geometry wherever required is suggested.

The improvements to the pavements, shoulders, medians & sidewalks are dealt in detail under this part. The drainage plan including kerbs etc are proposed to improve the condition of the road drainage system. The provision for lane marking & signs are made, wherever required.

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4.2 CAPACITY STANDARDS

Guidelines have been laid down in IRC: 64-1990 code for determining capacity standards for roads in India. The table shown below summarizes the capacity standards and design service volumes for various categories of roads in plain areas for the peak hour traffic of 8-10% and design service level corresponding to Level of Service-B (LoS B).

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Sl. No.	Type of Carriageway	Total Design service volumes for Different Categories of Urban Roads (PCU's PER HOUR)		
		Arterial	Sub-Arterial	Collector
1	2-Lane (One Way)	2400	1900	1400
2	2-Lane (Two Way)	1500	1200	900
3	3-Lane (One Way)	3600	2900	2200
4	4-Lane Un-divided (Two Way)	3000	2400	1800
5	2-Lane Divided (Two Way)	3600	2900	
6	6-Lane Un-Divided (Two Way)	4800	3800	
7	6-Lane Divided (Two Way)	5400	4300	
8	8- Lane Divided (Two Way)	7200		

* The values of LOS C in the above table are referred from IRC: 106-1990(Guidelines for capacity of Roads in Urban Areas)

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4.3 GEOMETRIC DESIGN

Design Speed

The arterial road has to be designed for a speed of 80 kmph. However, considering the land development, business establishment and other factors the reduced design speed of 50kmph was considered for the present road. Since IRC standards do not specify standards for median widths, raised or depressed median, shyness or edge strips etc., these have been recommended as per MoRT&H circulars.

Carriageway Width

The carriageway width for two lane with kerb shall be 4.8m and 10m for four lane with kerb as per IRC standards. The proposed width should be able to accommodate the projected traffic volume for the design life.

Footpath

Sufficient widths have been proposed for pedestrian movements along either side of the road with raised kerb and railing towards the carriageway edge ensuring better safety and comfort of pedestrian movements. The footpath should have a cross slope just to drain off the water. However, the width can be changed depending upon the expected pedestrian using this footpath.

Median

For six and more lane, the median provision should be made. However, for the safety and other aspects, median provision can be made four lane road, if the space is available. The absolute minimum width of median should be 1.20 m for urban areas.

Camber

Usually nominal camber of 2 to 2.5% is adopted depending upon the type of pavement. The bi-camber of 2.5% has been provided to this project road so as to ease drain off the water from the carriageway.

Transition Curves

As per IRC : 86 - 1983, Geometric Design Standards for Urban Roads in Plains, the length of the transition curve should be the larger of the two basis of the following criteria.

Rate of change of centrifugal acceleration, and

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Rate of change of super elevation (Not steeper than 1 in 150).

The value given in the IRC Geometric Design Standards for Rural Highways are obtained from the criterion of rate of change of centrifugal acceleration, with a pavement width of 7.00m. The transition length so obtained for various radii are presented in table below.

Minimum Transition Lengths

Radius (m)	Transition Length(m) 30Kmph	Transition Length(m) 50Kmph	Transition Length(m) 60Kmph	Transition Length(m) 80Kmph
30	80			
50	50	Not		
100	25	70	Not	
150	20	45	70	
200	15	35	50	Not
250	Not Required	30	40	85
300		25	35	75
400		20	25	55
500		Not Required	20	45
600			20	35
800			Not Required	30
1000				30

Kerb

A barrier type kerb should be adopted for the built-up areas with the adjacent footpath and considerable high pedestrian traffic.

Road Markings & Signs

Road Markings perform the important function of guiding and controlling traffic on a Road. The markings serve as psychological barriers and signify the delineation of traffic paths and their lateral clearance from traffic hazards for safe movement of traffic. Road

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markings are therefore essential to ensure smooth and orderly flow of traffic and to promote road safety. Road Markings and Road signs are given as per IRC: 35-1997 and IRC: 67-2001 respectively.

4.4 PAVEMENT DESIGN

The Benkelman Beam Deflection studies shall be conducted along the road stretch. The Corrected Characteristic Deflection from the BBD shall be used for the design of overlays as per the IRC requirements. Wherever, the BBD results are not available due to the damage of existing layers, the soil investigation to get the CBR shall be carried out and the design of full depth construction should be based on the test results.

4.5 STANDARDS & CODES OF PRACTICES

All activities related to field studies, design and documentation are done as per the latest guidelines/circulars of MoRT&H and relevant publications of the Indian Road Congress (IRC) and Bureau of Indian Standards (BIS).

All notations, abbreviations and symbols used in reports, documents and drawings are as per IRC: 71.

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CHAPTER 5

DESIGN AND RECOMMENDATIONS

5.1 OVERLAY DESIGN

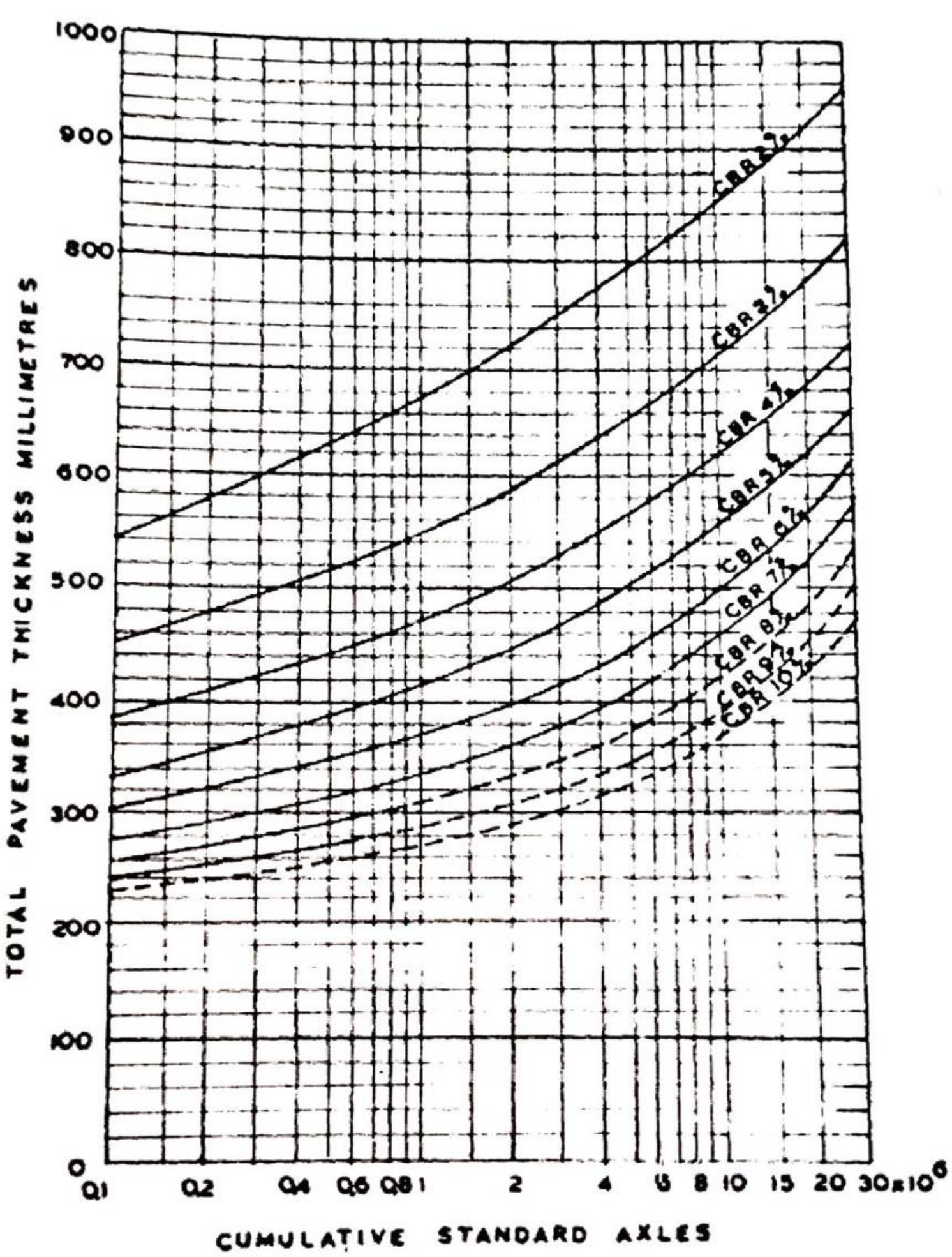

Fig. 1. Pavement thickness design chart

Note: 1. Read total pavement thickness from continuous curves
2. Use dotted curves for proportioning sub-base thickness

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5.2 CRUST DESIGN

The widening portion of the road stretch was designed using the IRC 37-2001. The soil samples conducted at these stretches and the average CBR value is 9% obtained. From the plate1 of IRC 37, the pavement composition is obtained. As per the design, the recommended thickness of pavement is given.

5.3 RECOMMENDATIONS

The recommendations for various components of road are described below in detail.

Drains

Existing Pre-Cast Slabs and BS slabs are to be removed and re-fixed. And New Pre-Cast Slabs and BS slabs are provided for missing or broken slabs if any.

Footpaths

Existing footpaths are not disturbed as the tiles has been provided at majors parts of the project road. However cobble stone has been proposed for missing or damaged footpath.

Road

BWSSB road cutting has been observed on the project roads. For restoration and wet mix macadam has been proposed. Potholes and damaged surfaces has been identified and rectification has been proposed. For entire length Bituminous Concrete of 40mm has been proposed.

Road marking and signs

Road Markings and Road signs are proposed as per IRC: 35-1997 and IRC: 67-2001 respectively for the ease movement of traffic. Typical cross section drawing are enclosed in Annexure.

5.4 SOIL INVESTIGATION REPORT

The soil sample collected as per IRC at stretches where the existing pavement is damaged and tests are conducted at laboratory. The grain size analysis, Optimum moisture content, dry density, CBR tests are carried out. From the results, the new crust depth has been designed for the traffic volume as per IRC 38- 2001.

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Correction for seasonal variations: Correction for seasonal variation depends upon the type of subgrade soil, its field moisture content and the average annual rainfall in the area. For this purpose, subgrade soils have been divided into three broad categories, namely, sandy/gravely, clayey with low plasticity (PI <= 15) and clayey with high plasticity (PI > 15). Similarly, annual rainfall has been divided into two categories, namely, low rainfall (annual rainfall <= 1300mm) and high rainfall (annual rainfall > 1300mm). Moisture correction factors are obtained from the graphs given in IRC: 81 – 1997 for different combinations of soil type and annual rainfall.

The soil samples were tested for moisture content, liquid limit and plastic limit in the laboratory. The plasticity index of the soil was obtained as a difference between the liquid limit and the plastic limit. Moisture content correction was applied to the observed deflection values as per the guidelines in IRC: 81 – 1997 for low rainfall.

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CHAPTER 6

COST ESTIMATES & RATE ANALYSIS

6.1 COST ESTIMATES

General

This chapter deals with the derivation of cost for the construction of the road. The rates of construction items are finalized based on public works deportment schedule of rates, Bangalore circle for the year 2015-2016 with rate analysis was carried out for each item with revised material rates and lead charges as applicable.

Pavement and Formation details

The proposed pavement and formation details are discussed in the earlier chapters. To derive the direct cost, Existing carriageway with Kerb on either side has been considered throughout the stretch.

Roadside Drainage

Proper drainage system has been adopted for the project road. Desilting of existing drains and resetting of cover slabs Has been Proposed.

Material Rates

The material rates adopted are based on rates from public welfare departments. Schedule of rates, Bangalore circle for the year 2015-2016 has been adopted. Table below gives the material rates adopted for different items. The rates of cement and steel are considered. The rates for bitumen have been considered based on the revisions/amendments by the PWD.

Machinery and Labour rates

The rates of machinery and labour were considered as that mentioned in the schedule of rates.

Lead charges

Lead charges for 20 km is considered for earth work and dismantling and considering cement, sand at available locations.

6.2 RATE ANALYSIS

Unit rates are those which when applied to quantities yield the direct cost of construction. The analysis of rates was done taking into consideration the rates for finished items from PWD schedule and adding lead as applicable. For items not included in the schedule, separate rate analysis has been carried out to derive at the finished item rate and for some items present market rates have been taken and considering an area

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weightage of 8% on SR basic rate for each item of work as this project fall under Bruhat Bengaluru Mahanagara Palike limits (BBMP Limits).

Contingencies

Around 2% of the total cost is considered for PMC and other charges.

Construction cost items

The Cost items include a series of elements that added together will give the construction cost. The elements of construction cost for this study are described below.

Construction cost

These includes all physical work relating to the road construction such as desilting of existing drains, site clearance, earthworks, pavement surfacing, drainage, structures, road furniture etc. These cost are calculated from the estimated quantities and basic rates. Direct cost indicates the cost of rehabilitation of existing carriageway width, footpaths on either side of the road.

Base cost

Construction costs along with PMC and escalation forms the base cost The Cost Estimates & Rate Analysis of the Road is given.

6.3 BBD STUDY

The Benkelman Beam Deflection (BBD) study was carried out on Brindavana Road.

In order to evaluate the structural condition of existing pavement, Benkelman beam deflection studies were carried out as per IRC 81:1997. The sub grade soil investigations are done wherever necessary. The rebound deflection values obtained are shown in Table 1.

- **BENKELMAN BEAM DEFLECTION STUDIES**

The Benkelman Beam rebound deflection studies were conducted on the selected stretches as per the recommendations of IRC: 81 – 1997. A standard truck with a rear

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axle load of 8170 kg fitted with dual tyres inflated to a pressure of 5.60 kg/cm2 was used to conduct the rebound deflection studies on the road pavement.

- LOCATION OF STUDY STRETCH

The Benkelman Beam deflection studies were conducted on Brindavana Road.

Field Studies

The Benkelman Beam Deflection studies were carried out along specified stretches as per the procedure suggested by IRC: 81-1997. In each kilometer stretch, deflection observations were recorded along the outer wheel paths. As per the guidelines, the markings on the pavement surface were staggered. A standard truck with a rear axle load of 8170 kg fitted with dual tyres inflated to a pressure of 5.60 kg/cm2 is made to stop such that the dual wheels are centered above the selected point. The probe of the Benkelman Beam is inserted between the dual wheels and placed on the selected point. The initial reading of the dial gauge (d0) is recorded. The truck is slowly driven forward by 2.7m and the intermediate reading of the dial gauge (di) is recorded. The truck is driven forward by a further 9m and the final reading of the dial gauge (df) is recorded. Benkelman Beam deflection studied carried out is shown in photographs.

The pavement temperature influences deflection measured by the Benkelman Beam. For the purpose of design, all deflection values measured should be related to a common temperature. Measurements made when the pavement temperature is different than the standard temperature needs to be corrected. Hence the pavement surface temperature was also measured. The pavement temperature was measured at a depth of 40 mm on the bituminous layer using a short stem thermometer after filling the hole with glycerol. Pavement deflections are also affected by seasonal variations in climate. The subgrade soil samples were collected from the wheel paths where deflection studies were conducted after digging and removing the pavement materials up to the subgrade level and collecting soil samples in airtight polythene bags and brought to the laboratory for further tests.

- Analysis of Data

The Benkelman Beam deflection data obtained as per IRC: 81 – 1997 was analyzed. The raw data consisted of initial (do), intermediate (di) and final deflection (df)

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values at equal intervals. The rebound deflection values obtained in each stretch were used to calculate the statistical parameters viz., mean and standard deviation.

Correction for temperature variations: The stiffness of bituminous layers changes with temperature of the binder and consequently the surface deflections of a given pavement vary depending on the temperature of constituent bituminous layers. It is necessary that the measured deflection values be corrected to a standard temperature. As per IRC: 81 – 1997, correction for temperature variation on deflection values measured at pavement temperature other than 35°C is specified as 0.01mm for each degree centigrade change from the standard temperature of 35°C. The correction is positive for temperature lower than 35°C and negative for temperature higher than 35°C.

The correction for temperature variations was accordingly applied to the deflection values obtained.

Correction for seasonal variations: Correction for seasonal variation depends upon the type of subgrade soil, its field moisture content (at the time of deflection survey) and the average annual rainfall in the area. For this purpose, subgrade soils have been divided into three broad categories, namely, sandy/gravely, clayey with low plasticity (PI <= 15) and clayey with high plasticity (PI > 15). Similarly, annual rainfall has been divided into two categories, namely, low rainfall (annual rainfall <= 1300mm) and high rainfall (annual rainfall > 1300mm). Moisture correction factors are obtained from the graphs given in IRC: 81 – 1997 for different combinations of soil type and annual rainfall.

The soil samples were tested for moisture content, liquid limit and plastic limit in the laboratory. The plasticity index of the soil was obtained as a difference between the liquid limit and the plastic limit. Moisture content correction was applied to the observed deflection values as per the guidelines in IRC: 81 – 1997 for low rainfall.

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